DESCRIPTIONS...

CIRCULATORY SYSTEM

How would you like to sign up for Puffy Face / Chicken Leg Syndrome? Sound fun and exciting? Actually, quite a few people want this to happen to them, or at least they tolerate it to accomplish something else. What would someone do to have a puffy face? Anyone that goes into space experiences having uncomfortable, stuffy sinuses, a puffy face, and skinny, bony legs. You have probably experienced this to some degree if you have stood on your head or lied down on a hill with your head downhill. Try to tolerate that for an extended period of time. It is not very comfortable and any astronaut can tell you that.

The cardiovascular system is made up of the heart, arteries, capillaries, and veins. It is responsible for moving blood to all of the cells, tissues, organs, and systems of the body, including itself. Red Blood Cells pick up oxygen when going through capillaries in the lungs. The heart pumps oxygen-rich blood through arteries to capillaries in tissues which give cells oxygen and nutrients. The cells give off wastes, including carbon dioxide into the capillaries which the Red Blood Cells return to the heart through veins. The heart pumps the blood back to the lungs' capillaries where the oxygen / carbon dioxide exchange happens again. When blood leaves the heart, it is under pressure in the arteries. When it returns in veins, it has much less pressure. Our bodies fight gravity by having valves in the veins that keep blood from going backwards. Blood moves with less pressure out of our legs since, most of the time, our head is above our legs. By having a sort of "reserve" of extra fluid in the legs, our body makes sure to keep blood in the most important part of our body, the brain.

In space, astronauts' bodies do not fight gravity. Blood moves out of the legs much easier but the body still works just as hard to get blood to the brain. The legs get skinnier and the face gets puffier (which has the beneficial effect of temporarily pushing out wrinkles). Eventually, the body realizes that it does not need as much fluid and it flushes it out in the urine. The legs stay skinny but the head rush subsides. One problem with this however, is on Landing Day when the body needs to get all that fluid back. As a countermeasure, or a way to counteract the effect, astronauts practice "fluid loading" trying to drink enough water and maintain it in their systems. Without enough fluid to fill the legs and get blood to the brain, astronauts can get dizzy spells and may even pass out after they land and try to stand up. This is called hypotension or low blood pressure. Have you ever stood up too fast and gotten dizzy? You may have a taste of how astronauts feel when they return to Earth.

DIGESTIVE SYSTEM

Have you ever felt like you had butterflies in your stomach? Maybe you have ridden a roller coaster that made your stomach churn. The motion might make you lose your appetite or give you gas or even make you throw up food you had already eaten. In space, astronauts have to work in conditions where their bodies are always floating around. They lose their desire to eat because of stomach problems or from eating the same kinds of foods everyday. Their digestive tracts do not absorb medication as easily in space as on Earth. They can even develop constipation while on orbit.

The digestive system begins with the mouth where food is chewed and moistened with saliva for easier swallowing and digesting. The chewed food travels through the throat and into the esophagus or "food tube." The esophagus carries the food to the stomach where acids churn with the stomach's muscles to break the food down. The food continues to break down along its journey through the small and large intestines with the help of the pancreas and liver. The nutrients and water are pulled out, until it reaches the anus and leaves the body as feces. Throughout the entire system, smooth muscles along the digestive tract push the food down with a mechanism called peristalsis.
Peristalsis even works upside-down against the force of gravity as well as in space without the pull of gravity. However, foods have to be specially packaged for Space compared to on Earth. Many foods are not eaten in Space because of the hazards they can cause. Crumbs in the computers can be a large problem so astronauts eat sandwiches on tortillas rather than bread. The first American to eat food in space was John Glenn when he ate applesauce from a tube on Mercury 6. You may not meet a group so excited to get fresh fruits and vegetables as astronauts. Normally, their food is dehydrated and packaged, so fresh produce is a wonderful treat.

After eating the food, going to the bathroom in space is not as easy as on Earth either. Until the Skylab Program, toilets were not available to astronauts. The Gemini and Apollo Programs taped storage bags to the buttocks for fecal collection. Today, astronauts use a toilet that looks similar to toilets on Earth. One large difference is that astronauts have to be strapped to the toilet so they do not float away. The toilet has an airflow that draws the feces into a storage receptacle for later disposal upon their return to Earth. Just another one of the challenges of space travel.

WHAT HAPPENS TO OUR BODY IN SPACE?

IMMUNE SYSTEM

Stress. Sometimes events in our lives like moving, going to a new school, or a death in the family cause stress. Maybe someone has to catch up with school assignments or is behind at work. Too much stress can make someone's immune system, the part of the body that prevents illness, get weaker. The tasks of an astronaut can be very stressful so being aware of the stress and making it tolerable is very important to a successful mission.

The immune system is the body's protection from bacteria and viruses. The first line of protection is the skin which keeps microbes from entering the body. Places that are at risk for infections are openings in the skin whether they are natural, anatomical holes like the eyes and ears or they are open wounds. The body produces tears, saliva, and mucous to protect these openings but if bacteria or viruses get through, the white blood cells take over. One way that white blood cells, specifically lymphocytes, fight toxins is by creating antibodies. After a lymphocyte meets a toxin or antigen, it creates antibodies that bond with the antigen and prevent it from doing any damage. Another way lymphocytes stop invaders is by wrapping themselves around a virus or tumor cell and essentially "eating" it. This is called phagocytosis.

Bacteria, viruses, and tumor cells are then moved through vessels of the lymphatic system to be caught in lymph nodes. The spleen, thymus, and bone marrow also play roles in the immune system. After missions, astronauts seem to have a lowered immune system especially for missions over 4 days long. Determining the causes and stresses of their weakened condition will continue to be important for extended missions. One way to prevent getting sick before a mission is to separate, or quarantine, the crew from others. However, it is possible for the crew to repeatedly share antigens with each other, particularly on long missions to the Moon or Mars, for example. Bouncing antigens back and forth may cause allergic reactions as well, so more study needs to be done to prevent "catching colds" in space.

INTEGUMENTARY SYSTEM

Wash behind your ears. Make sure to scrub your face. Staying clean is an important part of good health. Washing and scrubbing with soap and water is sometimes difficult enough to do at home. What happens if your soap floats away? What would you do if you only got a cup of water to wash your body? In space, astronauts have to keep themselves clean, too, but it can be much more difficult.

The integumentary system includes the skin, hair, finger and toe nails, and glands of the skin. This system keeps us warm by holding in body heat, protects us from disease by blocking out germs, and provides a flexible container for movement. The skin contains glands that produce sweat for keeping the body cool and oil for keeping the skin soft and pliable. While on space walks, or extravehicular activities (EVAs), astronauts are kept cool by wearing long underwear with a football field length of tubing woven through it. This tubing pipes cool water around the astronaut to prevent sweating, which would not only be stinky, but also would cause a loss of fluids and dehydration.

Cleaning up oneself in microgravity is difficult because soap and water float. Without gravity to pull it down, water does not fall off one's body but rather sticks to it like on the walls in a shower. Astronauts move it around to clean themselves but because of the effects of microgravity, they can develop rashes or acne. Consider a contagious skin disease on Earth. Now, think about what would happen if the particles of that disease started to float where you might breathe them in. This is another reason astronauts try to keep very clean. Another issue with the skin is injury due to cuts and scrapes. No official studies have been done on this but astronauts tell stories about how they accidentally cut themselves sometimes, and how the cuts do not heal until they return to Earth. Another question to answer that may be waiting for you to figure it out!

MUSCULAR SYSTEM

If you have broken your arm or leg before, you know what it is like to take off the cast and feel weakness in that limb. Why is it so weak? What was the cast doing to it? To help your body to heal, the cast makes sure you do not move the broken body part. Without moving it, the muscles get weaker and you may have to rehabilitate them with exercise. Weight-lifting is great for building muscles on Earth. You push or pull weights that are free or on cables and your muscles are stimulated to grow. On orbit, astronauts move massive objects as big as refrigerators without working up a sweat. Similar to being in a cast, astronauts are not using their muscles as much and therefore, their muscles get weaker.

There are actually three kinds of muscle: *skeletal*, *smooth*, and *cardiac* muscle. However, when most people think of muscles, they think of the weight-lifting kind, skeletal. These muscles are attached to bones to make them move and do work. Smooth muscles control things like the movement of food through your intestines or the size of arteries to control blood flow. Cardiac muscle is heart muscle and both it and smooth muscle are *involuntary*, meaning you do not control them. Skeletal muscles are muscles you control and are called *voluntary*.

All of these muscles are affected in space. Large objects are easier to move, smooth muscle does not need to fight against gravity and neither does your heart. Astronauts do exercises in space, sometimes two hours or

more every day. They have to keep their hearts strong and skeletal muscles toned but no matter how much exercise they do, they still get weaker while in space. When looking at astronaut muscle tissue under a microscope, you can even see the appearance of fat cells after a flight. Were they there before but too small to see? Were they muscle cells that turned into fat cells? More study is still needed to find out. Upon their return to Earth, astronauts have to go through rehabilitation to regain their strength and recondition their muscles. Staying healthy is a job in itself sometimes.

NERVOUS SYSTEM

Have you ever stayed up all night? The next day you were probably quite tired and maybe you could not think as quickly as usual. You might have had to go to sleep even while the sun was up. Sometimes people work nights and have to sleep during the day. They adjust to a different sleep pattern than most humans but even in daylight they can get their necessary amount of sleep. However, what happens if you only see daylight for an hour followed by an hour of nighttime? What if you have to live with a sunrise or sunset every 46 minutes for two weeks? How about for two months? What about for two years? Now, add the fact that you cannot leave your home and you have to perform experiments on a tight time schedule, away from your friends and family. Plus, you are surrounded by only a few people that may have very different backgrounds and not share a common first language. On top of this, you are floating in microgravity!

Spaceflight can have a very significant impact on an astronaut's mental and physical health. The brain, spinal cord, and nerves control the body and its functions. Changes in the normal patterns can cause: slower thinking, impaired attention, poor memory, slower reaction time, sleepiness, mood changes, and reactions to stress. It can also affect hormone production. Astronauts are people, too, and regularly scheduled sleep, work, and relaxation time are necessary to maintain good mental health. On the International Space Station (ISS), the astronauts and cosmonauts plus all of the Mission Control staff in Houston, Texas and Star City, Russia, set their watches to Greenwich Mean Time. With the ISS going through 24 time zones within 92 minutes, staff on the ground keep a consistent time to reduce confusion.

Astronauts also get time to talk with friends and family over e-mail or in the occasional teleconference. Windows also provide scenery for astronauts to gaze out at Earth, when they have time to look. To prepare for the isolation and pressure of working in space, astronauts and cosmonauts undergo much education and training to help them to work as a team. They may even have to camp with minimal supplies and be given a large number of tasks to complete somewhere as remote as Antarctica or as isolated as an underwater habitat. The harsh conditions of space can make tasks very frustrating. This makes teamwork very important to working in space and a large component of how well a crew performs their duties while on orbit.

RESPIRATORY SYSTEM

Can't catch your breath? Well, at least you do not have to bring your air with you wherever you go. When astronauts travel out of Earth's atmosphere, they have to bring breathable air with them. What if there are poisons in the air or they run out of oxygen? There are many considerations that engineers and scientists have to take into account when they design spacecraft for humans to live in.

The respiratory system brings in the necessary oxygen for your body to function while removing the body's waste gas, carbon dioxide. Air comes in through the mouth or nose where it gains humidity and warmth making the air moist for taking down through the "wind pipe," or trachea, and into the lungs. The tubes in the lungs branch out like roots, getting smaller and smaller until they reach the alveoli. Alveoli look like tiny bunches of grapes wrapped with microscopic blood vessels called capillaries. At this level, oxygen leaves the alveoli to go into the capillaries and the capillaries give up carbon dioxide to enter the alveoli. This is called a gas exchange. In space, studies show that astronauts have a better gas exchange than on Earth, partially due to larger capillary size.

Air on Earth has about 21% oxygen and 78% nitrogen with trace amounts of other gases. The Space Shuttle and International Space Station have about the same environment as well as a liquid-air exchange system to control temperature and humidity. When astronauts use their space suits to go outside of the vehicle in an extravehicular activity (EVA), they prepare themselves by sitting in an airlock with 100% oxygen. This helps them to prevent developing medical problems similar to those of SCUBA diving such as "the bends." Then, they take their atmosphere with them in their own mini spacecraft, the EVA suit. The suit has oxygen for breathing filters for cleaning the air and dehumidifying it, and pressure to create a similar environment to the inside of the Space Shuttle. Gaining the freedom of a space walk means gaining dependence upon life support systems, but would you turn down the chance to do an EVA?

SKELETAL SYSTEM

Instead of going to school or work, would it not be great to just sit on the couch or lie in bed all day? Working on a computer or watching TV without moving a muscle sounds quite appealing. What if you could get paid to rest, would you like that job? What if you had to rest for a whole week? How about 2-4 months? NASA is researching what happens to people's bones and muscles with after long periods of bed rest. Why? When on orbit, astronauts use their bones and muscles but they do not have to stand up straight or hold up their heads. If an astronaut raises his or her hand it will just stay there until they move it somewhere else. Without the force of

gravity pulling them down they have almost no "loading" or weight bearing. This has similarities to bed rest studies.

The human skeleton is made of 206 bones and weighs about 9 kilograms (20 pounds) in adults. The bones support the body's weight, protect vital organs and tissues, provide attachment of muscles for movement, store mineral salts of phosphorus and calcium, and produce blood cells. Bones can be flat, long, short, irregular and

have three main parts. The outer layer of the bone is a white skin called the *periosteum*. Beneath this is *compact bone* which has cells and tissues as well as a hardened, calcified material. These two are full of holes to allow blood vessels and nerves to reach into the third part of the bone, *bone marrow*. Here, white blood cells, red blood cells, and platelets are formed.

Three types of cells maintain the bones. *Osteoblasts* build bone. *Osteoclasts* break down bone. *Osteocytes* are mature bone cells. Young, growing people have more active osteoblasts building the bone. As people reach adulthood, the building and breaking down balance out. As people get older, the breakdown of bone increases causing *osteoporosis,* or "porous bone." Without the loading that we feel with gravity, the bones lose calcium in space also. In fact, on average astronauts lose 1% of their bone mass per month in space. In some 4-6 month missions, 10% bone loss was found. Exercise seems to slow down the loss of bone but nothing seems to stop it. Do the osteoblasts stop building bone? Do osteoclasts break it down faster? Do they not know which way to grow? Do they change into other types of cells? There are many questions about how to stop this from happening. Maybe you have the answer.

URINARY SYSTEM

When someone is sick we often hear, "Make sure to drink plenty of fluids." We drink fluids, primarily water, to "flush out" what our bodies are trying to get rid of. The kidneys are very good at removing excess components in our bodies, as long as they dissolve in water (water-soluble). Some say taking excess vitamins makes for expensive urine because the body removes what it does not need. If you already have enough vitamin C from fruits and vegetables, getting more of it in a pill will all be flushed out of the body. In space, the body thinks it has too much fluid altogether! Astronauts are told to drink plenty of fluids even though they are *not* sick.

The most important parts of the urinary system are the kidneys. Kidneys are about half the size of your fist and shaped like kidney beans – see the connection? They filter the blood of excess dissolved materials and they use water to flush the surplus out. One excess in space happens because the skeletal system does not stay as strong. As bones lose calcium, calcium can collect in the kidneys and form crystals called kidney stones. Kidney stones have to be passed through the same way as urine but they are hard and can block the pathway. Many doctors say that passing a kidney stone is close in pain to giving birth.

Here is the path that stones and urine have to take. The urine produced from each kidney goes down ureters to the bladder. When the bladder senses that it is full enough, a signal is sent to the brain that lets the person know that it is time to "relieve the pressure." Urine is allowed to go down the urethra out to the environment. When your environment is on Earth, you just need to make sure the proper receptacle is below you to catch the urine. If you are in space, urine goes out in the direction it is sent. That is why astronauts each have a tube to urinate into that has a negative pressure or a slight vacuum effect. In space, water is a precious commodity so on the International Space Station, astronauts may see this fluid again as the urine is purified and made into drinking water! Make sure to drink plenty of fluids!

NUCLEAR ENVELOPE

Have you ever spun around in circles, maybe with your head down on the end of a baseball bat, and then tried to walk or run in a straight line? Maybe you have sat in a swivel chair that can spin around and around at a rapid speed and gotten dizzy from that? Imagine feeling dizzy and disoriented for up to three days straight. Some astronauts have to deal with dizziness when they go up into space even without spinning.

The vestibular system is found in the inner ear and is made of several sacs and semicircular canals that contain fluid and motion-sensing hair cells. The sacs are called otolith organs and have crystals embedded in a gelatin-like material. One of the sacs lies along a horizontal plane while the other is vertical. When you accelerate forward and backward or up and down, these crystals move and are detected by hair cells. The semicircular canals are rings positioned at right angles to each other with fluid and motion-sensing hairs as well.

Imagine what these fluids and crystals do on Earth, falling to whichever part is nearest to the ground. Imagine doing a somersault and how the fluids might move through the tubes. Now, picture how they would move without the pull of gravity. When the vestibular nerve sends information to the brain, the brain may not be able to adjust to a new environment such as space. On Earth, when you spin around in circles and stop, sometimes it feels like you are still spinning because those fluids are still moving. In space, they just keep moving and floating. Your brain uses the information from the vestibular system along with your eyes and special nerves in your muscles, joints, and skin to make sense of your position whether you are sitting still, turning cartwheels, or floating in space. Keep that in mind next time you spin around with your head on a baseball bat.